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EXAMINER

PATEL, NIRAV B

ART UNIT PAPER NUMBER

2135

DATE MAILED: 07/12/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

## Office Action Summary

Application No.

10/051,276

Applicant(s)

SHIMBO ET AL.

Examiner

Nirav Patel

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 1/22/02.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-16 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-16 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 22 January 2002 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☒ All b) ☐ Some \* c) ☐ None of:
1. ☒ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- \* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)  
Paper No(s)/Mail Date (1)1/22/02.
- 4) ☐ Interview Summary (PTO-413)  
Paper No(s)/Mail Date. \_\_\_\_\_.
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: \_\_\_\_\_.

### DETAILED ACTION

1. This action is in response to the application filed on 1/22/2002.
2. Claims 1-16 are under examination.

### Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

3. Claims 1-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Iwamura et al. (US Patent No. 5,321,752) and further in view of Sathi Perumal ("Pipelined 50 MHz CMOS ASIC for 32 bit Binary to residue conversion and residue to binary conversion" 1994).

As per claim 1, Iwamura teaches:

*A modular exponentiation calculation apparatus [col. 6 lines 5-9 "a communication apparatus which performs encryption or decryption of a communication content by using a modular exponentiation  $C=M^e \bmod N$  concerning integers M and e using N as the modulus, the communication apparatus comprising"] which utilizes a residue number system [col. 3 lines 50-53 "modular exponentiation and modular multiplication employed in cryptic communication is executed simply by repeating modular multiplication using R which is prime to N which is the*

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**residue”]** representation by a first base and a second base including sets of a plurality of integers with respect to object data C and parameters p, q, d (all integers included in both the bases are mutually primary, a product "A" of all the integers of the first base is  $A > p$ ,  $A > q$ , a product "B" of all the integers of the second base is  $B > p$ ,  $B > q$ , and  $A \times B > C$ ) to obtain a calculation result  $m = C^d \bmod (p \times q)$  [**col. 4 lines 40-41 “the modular exponentiation  $C = M^e \bmod N$  is executed”, col. 1 lines 13-24 “computation known as modular exponentiation which is expressed by  $C = M^e \bmod N(C, M, N, e)$ , where E, M, N and e are integers”]**, said apparatus comprising:

a first processing unit configured to obtain a residue number system representation of a value  $Cp^{dp} \times B \bmod p$  or a value with p added thereto based on a residue number system representation of a remainder value  $Cp = C \bmod p$  by p of said data C and a remainder value  $dp = d \bmod (p-1)$  by (p-1) of said parameter d [**col. 1 lines 14-24 “encryption of data to transmit and decryption of received cryptogram by using a computation in which two integers A and B are multiplied with each other and the product is divided by a third integer N to determine the residue, i.e., modular multiplication expressed by  $A \cdot B \bmod N$ ”, col. 3 lines 63-68, col. 4 lines 1-3 “executing a modular multiplication  $A \cdot B \bmod N$  of integers A and B by using N as the modulus, the communication apparatus having at least one computing unit which computes and outputs  $Z = U \cdot V \cdot R^{-1} \bmod N$  by using an integer R which is primer to N, the method comprising the steps of: inputting to one of the computing units A and a constant  $R_R$  which is expressed by  $R_R = R_2 \bmod N$ , thereby causing the computing unit to output  $A_R = A \cdot R_R \cdot R^{-1} \bmod N$ ” col. 9 lines**

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**65-68, col. 10 lines 1-2** “addition of  $E_{j-1}$  as the residue are conducted. That is,  $L_{j-1}$  is converted into  $E_{j-1}$  and the thus obtained  $E_{j-1}$  is added. By this method, all the subtractions made by mod  $N$  can be carried out by adding computations”];

a second processing unit configured to obtain a residue number system representation of a value  $Cp^{dp} \times B \bmod q$  or a value with  $q$  added thereto based on a residue number system representation of a remainder value  $Cq = C \bmod q$  by  $q$  of said data  $C$  and a remainder value  $dq = d \bmod (p-1)$  by  $(q-1)$  of said parameter  $d$  [**col. 4 lines 3-5** inputting to one of the computing units  $B$  and the constant  $R_R$  thereby causing the computing unit to output  $B_R = B \cdot R_R \cdot R^{-1} \bmod N$ ];

a third processing unit configured to obtain a residue number system representation of an integer  $m'$  congruent with  $m = C^d \bmod (p \times q)$  [**col. 4 line 23** “constant  $R_R$  which is expressed by  $R_R = R^2 \bmod N$ ”], based on both the residue number system representations obtained by said first and second processing units [**col. 4 lines 6-8** “inputting to the computing unit the  $A_R$  and  $B_R$  thereby causing the computing unit to output  $T_R = A_R \cdot B_R \cdot R^{-1} \bmod N$ ”]; and

Iwamura teaches the apparatus comprising four various processing unit (i.e. four various computing means **col. 6 lines 19-32**). Iwamura doesn't teach that calculate result by *converting RNS (residue number system) to binary* representation.

However, Sathi Perumal teaches the Residue to Binary conversion [**page 456 lines 23-25** “if two residue number  $Z1$  and  $Z2$  are known, then the binary number equivalent  $B$  can be calculated from (13)”].

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Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the teaching Sathi Perumal into the teaching of Iwamura to use RNS to Binary converter. The modification would be obvious because one of ordinary skill in the art would be motivated to use residue to binary converter (RBC) to convert the 8 RNS moduli words to a unique 32 bit binary number. The result is a complete simulated pipelined design which supports a clock frequency of 50 MHz **[Sathi Perumal, page 454 lines 5-10]**.

As per claim 2, the rejection of claim 1 is incorporated and further Iwamura teaches:

first processing unit performs a residue number system *Montgomery multiplication* of the residue number system representation of said remainder value  $C_p$  and the residue number system representation of  $B^2 \bmod p$  **[col. 27 lines 23-50 “in executing Montgomery modular multiplication, R is an integer prime to N on condition that R is determined to be  $2^n$  (n being an optional integer). In this case, the division by R can simply be performed by a bit-shift operation, so that the Montgomery modular multiplication of the formula (25) or (27) is executed simply by multiplication alone”]**, performs a residue number system *Montgomery exponentiation* using said remainder value  $d_p$  as an exponent portion with respect to the obtained residue number system representation, and thereby obtains the residue number system representation of the value  $C_p^{d_p} \times B \bmod p$  or the value with p added thereto **[col. 27 lines 52-66, col. 28 lines 1-9 “it is thus possible to carry out modular**

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exponentiation only by Montgomery modular multiplication. The initial value of  $C_R$  in formula (30) can be treated as a constant which is determined by  $R_R$  and  $N$ . The described modular exponentiation conducted through Montgomery modular multiplication alone will be referred to a Montgomery modular exponentiation", *col. 29 lines 47-50, col. 30 lines 1-2*], and

second processing unit performs a residue number system *Montgomery multiplication* of the residue number system representation of said remainder value  $C_q$  and the residue number system representation of  $B^2 \bmod q$  [*col. 27 lines 23-50* "in executing Montgomery modular multiplication,  $R$  is an integer prime to  $N$  on condition that  $R$  is determined to be  $2^n$  ( $n$  being an optional integer). In this case, the division by  $R$  can simply be performed by a bit-shift operation, so that the Montgomery modular multiplication of the formula (25) or (27) is executed simply by multiplication alone"], performs a *residue number system Montgomery exponentiation* using said remainder value  $d_q$  as the exponent portion with respect to the obtained residue number system representation, and thereby obtains the residue number system representation of the value  $C_p^{d_q} \times B \bmod q$  or the value with  $q$  added thereto [*col. 27 lines 52-66, col. 28 lines 1-9* "it is thus possible to carry out modular exponentiation only by Montgomery modular multiplication. The initial value of  $C_R$  in formula (30) can be treated as a constant which is determined by  $R_R$  and  $N$ . The described modular exponentiation conducted through Montgomery modular multiplication alone will be referred to a Montgomery modular exponentiation" *col. 29 lines 47-50, col. 30 lines 1-2*].

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As per claim 3, the rejection of claim 2 is incorporated and further Iwamura teaches:

a unit configured to obtain said *remainder value* (i.e. residue calculation)  $dp$  and said remainder value  $dq$  based on said parameters  $p$ ,  $q$ , and  $d$  [**col. 20 lines 20-30** " $S_{j-1, n-1} \cdot X^n + E_{j-1}$  is executed in place of executing  $Q_{j-1} \cdot N$ , so that the residue calculation is performed.  $S_{j-1, n-1} \cdot X^n$  is automatically performed due to the overflow of  $S_{j-1, n-1}$ , the residue calculation can be completed only by adding  $E_{j-1}$ "].

As per claim 4, the rejection of claim 1 is incorporated and further Iwamura teaches:

third processing unit performs a residue number system *Montgomery multiplication* of said residue number system representation obtained by said first processing unit and the residue number system representation of an inverse element  $q_{inv} = q^{-1} \bmod p$  in a modulus  $p$  of said parameter  $q$  [**col. 27 lines 16-18** "The Montgomery modular multiplication can be expressed as follows:

$T_R = A_R \cdot B_R \cdot R^{-1} \bmod N = (A_R \cdot B_R + M \cdot N) / R$ "], performs a *residue number system multiplication* (i.e. residue multiplication) of the obtained residue number system representation [**col. 18 lines 48-54** "the calculation of the RSA cryptography to be performed on the basis of the Chinese Remainder Theorem can basically be executed in parallel. Therefore, it is most suitable for use in the method according to the present invention in which the residue multiplication is executed by a plurality of calculating apparatus"] and the residue number system

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representation of said parameter  $q$ , performs a residue number system *Montgomery multiplication of said residue number system* representation obtained by said second processing unit and the residue number system representation of an inverse element  $p^{-1} \bmod q$  in a modulus  $q$  of said parameter  $p$  [col. 27 lines 16-18 "The Montgomery modular multiplication can be expressed as follows:

$T_R = A_R \cdot B_R \cdot R^{-1} \bmod N = (A_R \cdot B_R + M \cdot N) / R$ "], performs a *residue number system multiplication* of the obtained residue number system representation and the residue number system representation of said parameter  $p$  [col. 18 lines 48-54 "the calculation of the RSA cryptography to be performed on the basis of the Chinese Remainder Theorem can basically be executed in parallel. Therefore, it is most suitable for use in the method according to the present invention in which the residue multiplication is executed by a plurality of calculating apparatus"], performs a residue number system *addition* of both obtained results of a residue number system multiplication [col. 12 lines 14-16 "FIG. 3 illustrates a circuit for executing basic calculation  $R = R \cdot X + A_{n-j} \cdot B \bmod N$  of the residue multiplication and called a basic operator" (i.e. addition of residue multiplication)], and obtains the residue number system representation of the integer  $m'$  as the combination with  $C^d$  in said modulus  $p \times q$  (i.e. modular exponentiation) [col. 27 lines 52-68 "Modular exponentiation  $C = M^e \bmod N$  also can be conducted as follows by using Montgomery method" col. 28 lines 1-4 "it is thus possible to carry our modular exponentiation only by Montgomery modular multiplication"]].

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As per claim 5, the rejection of claim 4 is incorporated. Iwamura doesn't teach that convert the *binary representations to the RNS* (Residue number system).

However, Sathi Perumal teaches the Binary to residue conversion [**page 454, 455 equation (5) Fig. 2**].

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to incorporate the teaching of Sathi Perumal into the teaching of Iwamura to use Binary to residue converter. The modification would be obvious because one of ordinary skill in the art would be motivated to use BRC (Binary to residue Conversion) which employs a unique inverted tree structure that permits very fast clock frequencies while at the same time maintaining an area-efficient design [**Sathi Perumal page 454 lines 35-37**].

As per claim 6, the rejection of claim 5 is incorporated and further Iwamura teaches:  
unit configured to obtain the *inverse element*  $p_{inv}$  and the inverse element  $q_{inv}$  in the modulus  $p$  of said parameter  $q$  based on said parameters  $p$  and  $q$  [**col. 5 lines 14-16 "computing  $A_R \cdot B_R \cdot R^{-1} \bmod N$  on the basis of the computing results  $A_R$  and  $B_R$  and the  $R$ , thus determining  $T_R$  as the computation result; and computing  $T_R \cdot R^{-1} \bmod N$  on the basis of the  $T_R$  and the  $R$ "**].

As per claim 7, the rejection of claim 1 is incorporated and is rejected for the same reason set forth in the rejection of claim 3 above.

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As per claim 8, the rejection of claim 1 is incorporated and further Iwamura teaches:

a *storage unit* configured to store data of a residue number system representation depending only on said parameters  $p$ ,  $q$ ,  $d$  [**col. 6 lines 59-60 “fourth computing means which computing , upon receipt of  $C_r$  stored in the first storage means”**].

As per claim 9, the rejection of claim 1 is incorporated and is rejected for the same reason set forth in the rejection of claim 8 above.

As per claim 10, the rejection of claim 1 is incorporated and further Iwamura teaches:

first processing unit and said second processing unit execute at least a part of a processing at the *same time* (i.e. parallel processing or pipeline processing) [**Fig. 4 col. 12 lines 22-25 “The systolic array performs the calculation by a pipeline processing by PEs which are small and same functional blocks”**].

As per claim 11, the rejection of claim 1 is incorporated and is rejected for the same reason set forth in the rejection of claim 10 above.

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As per claim 12, the rejection of claim 1 is incorporated and further Iwamura teaches:

a unit configured to set a value of said integer  $m'$  less than  $p \times q$  obtained by the subunit or a value less than  $p \times q$  obtained by *subtracting* a predetermined number  $p \times q$  from said integer  $m'$  not less than  $p \times q$  to  $m = C^d \bmod p \times q$  [**col. 9 lines 65-68, col. 10 lines 1-2** “instead of execution of  $-Q_{j-1} \cdot N$  which is  $L_{j-1} \cdot X^n \bmod N$ , subtraction of  $L_{j-1} \cdot X^n$  and addition of  $E_{j-1}$  as the residue are conducted. That is,  $L_{j-1}$  is converted into  $E_{j-1}$  and the thus obtained  $E_{j-1}$  is added. By this method, all the subtractions made by mod  $N$  can be carried out by adding computations”].

As per claim 13, the rejection of claim 1 is incorporated and further Iwamura teaches:

the number of elements of said first base is the *same* as the number of elements of said second base [**col. 10 lines 57-59** “the modular exponentiation can be realized by repeating the modular multiplication  $C = C \cdot B \bmod N$  ( $B$  is  $M$  or  $C$ )”].

As per claim 14, it is a method claim corresponds to apparatus claim 1 and is rejected for the same reason set forth in the rejection of claim 1 above.

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As per claim 15, it is a computer usable medium claim corresponds to apparatus claim 1 and is rejected for the same reason set forth in the rejection of claim 1 above. Further Iwamura teaches that computer usable medium [**col. 8 line 31**].

As per claim 16, it is an apparatus claim corresponds to apparatus claim 1 and is rejected for the same reason set forth in the rejection of claim 1 above.

### **Conclusion**

4. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Blaker (US Pub No. 2002/0010730) discloses that Montgomery exponentiators and methods modulo exponentiate a generator (g) to a power of an exponent (e). The Montgomery exponentiators and methods include a first multiplier that is configured to repeatedly square a residue of the generator, to produce a series of first multiplier output values at a first multiplier output.

Hadad et al (US Patent No. 6,185,596) discloses that a modular arithmetic method and microelectronic apparatus therefore, operative to perform a sequence of interleaved Montgomery type multiplications and squaring operation, involves performing a sequence of modular multiplications and squaring using only a single carry save adder.

Chen et al (US Pub. No 2002/0120658) discloses the modular exponentiation function used in public key encryption and decryption systems is implemented in a standalone engine having at its core modular multiplication circuits which operate in two phases which share overlapping hardware structures.

Hobson et al (US 6,209,016) discloses a co-processor (FIG. 2) for performing modular multiplication comprising: means for receiving B and N binary data streams (bstr, nstr); means for receiving a data value A; adder means (Add1, Add2), subtractor means (Sub1, Sub2, Sub3) and multiplier means (Mul1, Mul2).

William L. Freking ("Montgomery modular multiplication and exponentiation in the residue number system" 1999) discloses new techniques are developed to aid in the residue number system (RNS).

Blum T. Paar ("Montgomery modular exponentiation on reconfigurable hardware", 1999) discloses the architectures that perform modular exponentiation with very long integers.

Jia-Lin Sheu ("A pipelined architecture of fast modular multiplication for RSA cryptography", 1998) discloses a fast algorithm with its corresponding VLSI architecture.

Ching-Chao Yang ("A new RSA cryptosystem hardware design based on Montgomery's algorithm", 1998) proposes a new algorithm based on Montgomery's algorithm to calculate modular multiplication that is the core arithmetic operation in an RSA cryptosystem.

Jean-Claude Bajard ("An RNS Montgomery Modular Multiplication Algorithm", 1998) presents a new RNS modular multiplication for very large operands. The algorithm is base on Montgomery's method adapted to mixed radix, and is performed using a Residue Number System.

Johann grobschadl ("The Chinese reminder theorem and its application in a high speed RSA crypto chip", 2000) presents the multiple architecture of the RSA crypto chip, a high-sped hardware accelerator for long integer modular arithmetic.

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M. Shand ("Fast Implementations of RSA Cryptography", 1993) discloses the critical techniques that may be combined in the design of fast hardware for RSA cryptography.


Any inquiry concerning this communication or earlier communications from the examiner should be directed to Nirav Patel whose telephone number is 571-272-5936. The examiner can normally be reached on 8 am - 4:30 pm (M-F).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kim Vu can be reached on 571-272-3859. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

NBP

7/6/05

  
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